

# A TEXTBOOK OF RADIOLOGY AND IMAGING

---

Best Available Copy

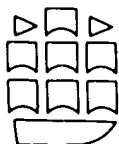
EDITED BY

**DAVID SUTTON**

M.D., F.R.C.P., F.R.C.R., D.M.R.D., M.C.A.R. (Hon.)  
Director, Radiological Department, St Mary's Hospital and Director of  
Radiology, St Mary's Hospital Medical School, London.  
Consultant Radiologist to the National Hospitals for Nervous Diseases  
(Queen Square and Maida Vale), London.

THIRD EDITION

*[Handwritten signature]*



CHURCHILL LIVINGSTONE  
EDINBURGH LONDON MELBOURNE AND NEW YORK 1980



## CHAPTER 29

### ARTERIOGRAPHY

There are two basic techniques in widespread use for arteriography:

- (1) Percutaneous needle puncture.
- (2) Percutaneous arterial catheterization.

The sites of arterial puncture are illustrated in Figure 29.1.

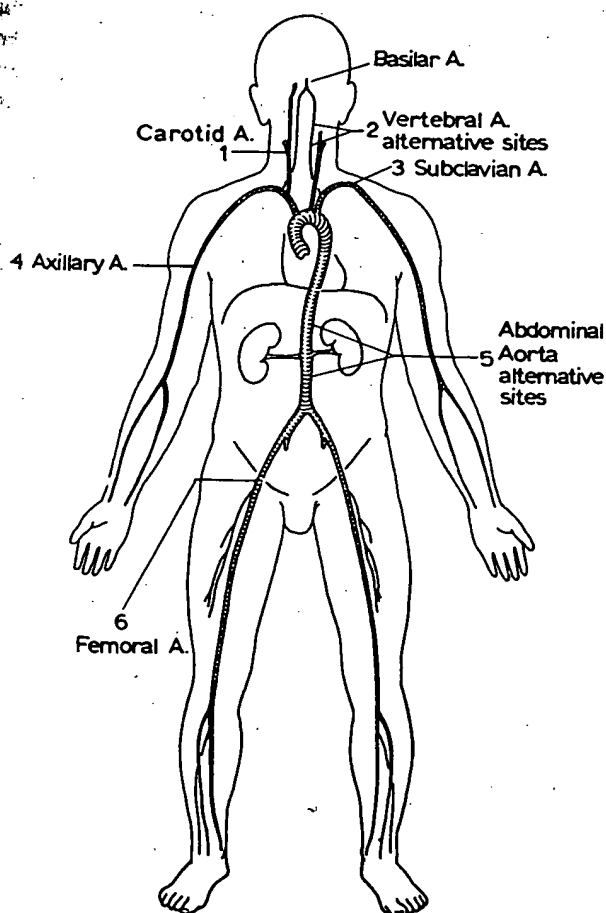


Fig. 29.1 Sites of arterial puncture. 1. Carotid artery. 2. Vertebral artery showing alternative sites. 3. Subclavian artery. 4. Axillary artery. 5. Abdominal aorta showing alternative sites. 6. Common femoral artery.

Sites of percutaneous catheterization. 6. Common femoral artery. 4. Axillary artery. 1. Carotid artery (rarely used).

#### PERCUTANEOUS NEEDLE PUNCTURE

The method has been applied to most areas of the body, and the investigations practised for the different areas include, or have included:

1. Head and neck:
  - (a) Common carotid arteriography.
  - (b) Vertebral arteriography.
2. The upper limb:
  - (a) Subclavian arteriography.
  - (b) Axillary arteriography.
  - (c) Brachial arteriography.
3. The lower limb:
  - Femoral arteriography.
4. The abdomen:
  - Lumbar aortography.

Needle puncture of the thoracic aorta has been practised in the past, but it was soon discarded as dangerous and replaced by percutaneous catheter techniques. Puncture of the subclavian or axillary artery was generally preferred to brachial artery puncture but is now rarely used, having also been replaced by transfemoral catheter techniques.

Arteriogram needles are usually of 18 British standard wire gauge (s.w.g.) (external diameter 1.2 mm) for routine work involving the carotid, vertebral, femoral, subclavian, and axillary arteries, although occasionally, and with children, the smaller 19 British s.w.g. (external diameter 1.0 mm) needle is used. For lumbar aortography a larger needle of 16 British s.w.g. (external diameter 1.6 mm) is used. All needles are about 12 cm long with the exception of the aortogram needle, which is about 20 cm in length.

It is important that the syringes should not be directly attached to the needle but joined to it by a flexible tube. This is built to withstand forced pressure injections and is made of transparent plastic tubing. These connecting systems are usually 20 to 30 cm in length, and care must also be taken that the injection syringes are suitable for the purpose. These must have a smooth easy action with no tendency to stick. The syringes for hand injection are usually of 10 ml, 20 ml or 30 ml capacity.

## PERCUTANEOUS ARTERIAL CATHETERIZATION

**Simple catheterization.** Percutaneous arterial catheterization is based upon the original work of Seldinger (1953) in Stockholm. The use of a Seldinger type needle and guide-wire permits the introduction of catheters percutaneously into arteries. The original Seldinger needle consists of a cannula with a central needle and stillette. Immediately after its introduction we modified this to a simpler needle of the same calibre as the cannula and with a shield mount (Seldinger-Sutton needle). The basic technique is illustrated in Figure 29.2. The most useful sites for the insertion of catheters into the arterial tree are:

1. The femoral artery in the groin.
2. The axillary artery in the axilla.

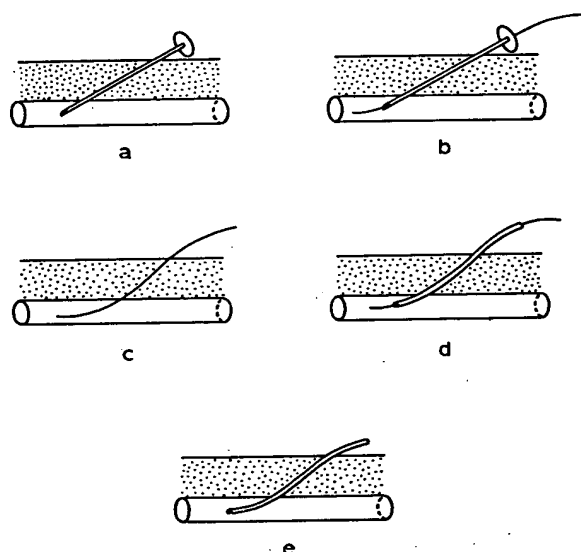


Fig. 29.2 Diagram to illustrate technique of percutaneous catheter insertion using the Seldinger-Sutton needle. (a) Needle inserted into artery. (b) Guide passed through needle into artery. (c) Needle withdrawn leaving guide in artery. (d) Catheter passed over guide into artery. (e) Guide withdrawn leaving catheter in artery.

Percutaneous catheters have also been inserted into the arterial system from the brachial artery just above the elbow, and from the common carotid artery in the neck. In practice the femoral or axillary arteries permit investigation of most areas. Thus a catheter passed from the femoral artery can be sited:

1. In the ipsilateral iliac artery.
2. High or low in the abdominal aorta.
3. High or low in the thoracic aorta.

Under image intensifier control a transfemoral catheter can also be passed up into the left subclavian artery in younger patients and on into the left vertebral artery if

required. It can also be passed around the aortic arch into the ascending aorta.

A transaxillary catheter can be passed into a subclavian artery and on the right side into the innominate artery, or into the aortic arch. It can sometimes be passed straight into a vertebral artery, particularly on the right side.

**Selective arterial catheterization** is a refinement of the technique just described. Radio-opaque catheters are preshaped for catheterization of individual branches of the aorta or great vessels. The method has been very widely used for renal angiography. It has also been extensively used for investigation of the coeliac axis, superior mesenteric and inferior mesenteric arteries. Other vessels which are frequently catheterized are the major branches of the aortic arch (innominate, left common carotid, and left subclavian arteries). Selective catheterization of the right subclavian and right common carotid arteries is also possible, as is catheterization of both internal carotid, external carotid and vertebral arteries; preshaped torque control catheters (Judkins, or 'head hunter' catheters) have been widely used for this purpose, as have the similar Cook catheters. Some workers prefer to preshape their own catheters using Kifa or Becton-Dickinson opaque tubing. The white Becton-Dickinson catheters popularized by Hannaford have the advantage of small external size but have less torque control. We prefer to use the Small Mani type catheters (French 5) for selective carotid and vertebral angiography. Cerebral angiography is discussed in detail in Chapter 61. Percutaneous selective coronary arteriography using Judkins catheters has now largely replaced the alternative cut down technique of Mason Somes.

Among smaller vessels which can be selectively catheterized are the internal mammary and thyroid axis arteries. Spinal angiography is also feasible by injection of the costo-cervical and intercostal arteries as well as the vertebral and lumbar arteries. Even tiny arteries like the bronchial or the adrenal arteries can be selectively injected.

**Super-selective arterial catheterization** is the term used for catheterization of branches of the coeliac axis such as the splenic, hepatic or gastroduodenal artery. This is achieved by advancing the catheter from the coeliac axis into its main branches. Superselective catheterization can also be carried out in branches of any of the major vessels including the external carotid artery and is being increasingly practised for embolization.

**Arterial cannulation** is similar to arterial catheterization, but the Seldinger cannula is advanced along the guide-wire so that its distal 2 or 3 cm lie along the lumen of the artery. Injections are then made directly through the cannula. The method has been mainly used for cerebral angiography (Ch. 61) but can also be applied to other vessels. For this technique Sheldon has replaced

the central Seldinger needle by a pointed trocar with the aid of which the arterial wall is first penetrated by the cannula. He also uses a very short guide-wire preset to a desired length by a movable restraining chuck at its hind end. The cannula is advanced along the arterial lumen, and once inserted it has the advantage that it is unlikely to become displaced as needles occasionally are. There is also less possibility of peri-arterial injection or sub-intimal injection.

### TECHNIQUE OF ARTERIAL PUNCTURE

The technique used for arterial needle puncture or catheterization is similar for most of the arteries injected.

The common femoral artery is usually punctured in the groin. The axillary artery is punctured in the axilla, with the patient's arm abducted. The common carotid artery is generally punctured below the carotid bifurcation.

In all the above cases the artery is fixed by the index and middle fingers of the palpating hand. Some workers prefer to fix the vessel by holding the fingers across the artery and others by placing the fingers along the course of the vessel. This is largely a matter of personal preference and experience.

Several of the arteries listed above are not accessible to palpation and different methods must therefore be used to localize and puncture them.

The *abdominal aorta* is approached from the left lumbar region with the patient lying prone. It is customary to take a preliminary X-ray film with markers placed over the lumbar spines so as to localize the levels of the vertebrae. Depending on the purpose of the injection, the operator punctures at different levels (Fig. 29.3). For renal angiography the puncture is made at about L.1 or opposite the L.1-2 disc space, i.e. about or just above the origin of the renal arteries. A similar point or one a little higher (D.12-L.1) is chosen when aortography is being performed to demonstrate an abdominal aneurysm or an aortic thrombosis. In cases of low aortic or iliac disease the puncture is usually made below the renal arteries (at about the upper border of L.3). In all the above cases, once the point of puncture has been chosen the needle is inserted from the flank at about a hand's breadth from the midline. For the higher puncture the needle is inserted obliquely upwards at an angle of about  $45^\circ$  but this angle is reduced for the lower punctures. In the latter case the skin puncture may also be made an inch or so farther out than with the higher punctures.

The *subclavian* artery may be punctured as it passes over the first rib. A skin puncture is made just behind the centre of the clavicle and the needle passed obliquely downwards to strike the anterior end of the first rib. By

using this as a guide the needle may be cautiously brought backwards along the rib and the subclavian artery entered. In this way it should be possible to avoid the brachial plexus or the apex of the lung. Alternatively the subclavian artery may be approached from below the clavicle. However direct subclavian puncture is now rarely required, since most workers prefer to inject the subclavian artery by transfemoral catheterization.

The *vertebral artery* can be punctured in the neck and several different approaches have been used (Ch. 61). It

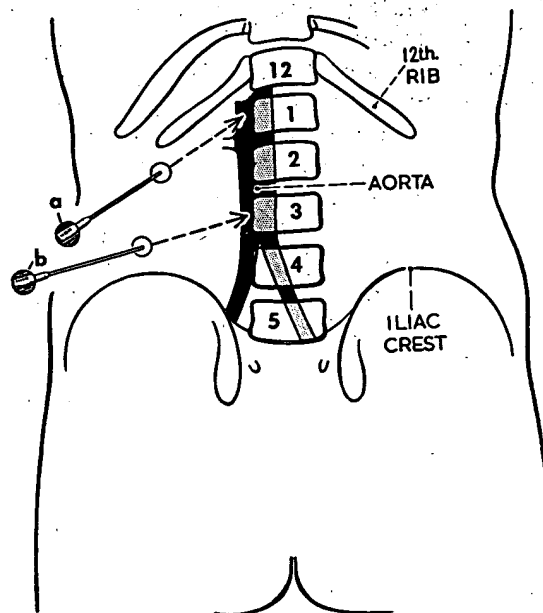


Fig. 29.3 Lumbar aortography: site of puncture. (a) High puncture. (b) Low puncture.

is now general practice to inject the vertebral artery by percutaneous catheterization, direct puncture being reserved for occasional cases where catheterization fails.

With all the above arteries the procedure, once the artery has been punctured, is similar. Successful puncture is marked by a rapid pulsation of arterial blood through the needle into the plastic tubing. The force with which this takes place will vary according to the size of the artery, but even with such small arteries as the vertebral the blood is under a definite arterial pressure which will readily and spontaneously press backwards the piston of the attached syringe.

As soon as this backflow of arterial blood is perceived, an assistant injects saline through the plastic system and needle into the artery. He continues to do this intermittently during the whole course of the investigation except for the actual contrast injections. The aim is to ensure that the needle remains correctly positioned in the artery and that it is kept clear of blood which may

clot in the needle or plastic tubing. Injection of contrast medium, in doses as described below, can then be made at the appropriate moment and after preparing the radiological apparatus for serial X-rays.

### TECHNIQUE OF PERCUTANEOUS CATHETERIZATION

The modified Seldinger's method as used by the writer is as follows, and can be divided into three stages (Fig. 29.2).

1. The artery (usually the femoral, less commonly the axillary) is punctured by a thin-walled Sutton needle. This has plastic tubing and a syringe attached, exactly as in the technique for simple needle arterial puncture. Once the needle is in the arterial lumen, saline is injected until all is ready for stage 2.

2. The plastic tubing and syringe are detached from the needle, which is held steady with its tip in the arterial lumen. There will be an immediate spurting of blood from the exposed end of the needle. The guide-wire which has a malleable tip in front is at once inserted through the needle and passed for a few centimetres along the artery till the stiff part is in the lumen. Holding the guide-wire firmly in this position the needle is then drawn backwards along it and off the guide-wire. Firm manual pressure is meanwhile applied through gauze swabs around the site of puncture in order to prevent haematoma formation. At this stage the guide-wire has been introduced percutaneously into the artery and all is ready for the final stage.

3. The catheter, which has been specially prepared and has a syringe attachment fixed at its hind end, is now passed along the guide-wire into the arterial lumen. The catheter is shorter in length than the guide-wire and as its front end reaches the skin the guide-wire protrudes backwards from the back end of the catheter. When the catheter is definitely in the arterial lumen the guide-wire can easily be extracted. Once the guide-wire is extracted there is a rush of arterial blood backwards through the catheter. A saline-loaded syringe, or a saline drip system, is immediately attached to the catheter and the latter is cleared of blood. Flow can be established or turned off by means of a tap at the catheter syringe attachment. The catheter can now be passed along the artery so that its tip lies at any desired level. In tortuous or atheromatous vessels it may be necessary to use special guides with flexible 'J' tips in order to advance the catheter through difficult areas and reach the desired level. Saline perfusion of the catheter is maintained either by slow hand injection, or by an automatic drip system. Heparinized saline is routinely used in order to counteract the tendency to clot formation around the catheter tip.

### TECHNIQUE OF SELECTIVE ARTERIAL CATHETERIZATION

The catheter is introduced into the aorta by the Seldinger percutaneous technique just described. The catheters used are radio-opaque and can be observed on a fluorescent screen. Their consistency is such that they can be preshaped to any desired form, for introduction into specific branches of the aorta. They are preshaped by dipping in sterile hot water and then setting them in sterile cold water after moulding. Alternatively, commercially made preshaped catheters can be used. Once the catheter is in the aortic lumen the radiologist observes its tip by screening with an image intensifier. By manipulating the free end, the tip is guided into the orifice of the artery chosen for injection. The use of an image intensifier is essential for this part of the procedure. Final manipulation of the catheter tip may also require special 'J' tip guide wires. These are made with varying curves of 3, 7 or 15 mm in diameter. Guide wires with special long floppy tips may also help in certain circumstances. This technique enables excellent angiograms to be obtained free of any overlying vascular shadows, and utilizing only small quantities of low-concentration contrast medium. Thus an excellent renal arteriogram can be obtained with only 8 ml of 60 per cent Urografin or of 45 per cent Hypaque.

### RADIOGRAPHIC APPARATUS

Arteriography usually requires rapid serial films of the area being investigated. In some areas, e.g. the lower limb, four serial films taken within about 5 to 8 seconds are usually adequate. In other areas, e.g. the aortic arch, films taken at 3 or 4 per second for 3 or 4 seconds may be necessary. In certain situations and with such lesions as arterio-venous fistula multiple rapid serial films may also be necessary.

Many types of serial changer are on the market for peripheral and cerebral studies. For studies requiring rapid serial work either the Schonander cut-film changer or the Elema roll-film rapid serial unit are usually used. The former allows speeds of up to 6 films per second, the latter even faster speeds (up to 12 films per second). The smaller Puck changer permits speeds of 3 films per second. Fine focus, high power tubes are vital in angiography to permit magnification techniques. Subtraction techniques are also widely used.

### Injection apparatus

Hand injection is perfectly satisfactory for many forms of arteriography, but pressure injection with special apparatus is essential for thoracic aortography and angiocardiology. Sophisticated and versatile apparatus commercially available for this purpose include the Swedish Cisol and the American Cordis and Medrad

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**